TITLE

INTERNALLY SHIELDED ENERGY CONDITIONER

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to United States provisional application 60/530,987, filed 12/22/2003, having attorney docket number X2YA0044P-US, and the contents of that application is incorporated herein by reference.

BACKGROUND OF THE INVENTION

This invention relates to electrical technology.

More specifically, this invention relates to low inductance devices and energy conditioning.

DISCUSSION OF THE BACKGROUND

The word "terminal" means electrically conductive material at the point at which current enters or leaves an electrical device.

The terms "X" capacitor and "line to line capacitor" both mean a two terminal passive lumped circuit element having a capacitance value across the two terminals wherein the two terminals are connected in parallel configuration with a circuit load device. X capacitors are primarily used to prevent electrical droop across loads. That is, X capacitors are typically used to provide a source or sink of electrical energy.

The terms "Y" capacitor and "line to ground capacitor" both mean a two terminal passive lumped circuit element having a capacitance value across the two terminals wherein one of the two terminals is connected to a line which is located in a circuit path between a source and a load and the other terminal is connected to an electrically conductive structure that, in lumped circuit diagrams, is usually shown as a ground. However, the voltage potential of the alleged ground may vary depending upon the amount of charge it receives or

distributes. In applications, typically, the alleged ground typically is either an earth ground or a chassis ground. However, for purposes of this application, the internal shield structure described below generally is not electrically connected to an external earth or chassis ground. Y capacitors are primarily used to filter noise from signals.

One or more lumped circuit elements including X and/or Y capacitors may be fabricated in a single structurally integral electrical device.

The term "plate" is used throughout to refer to structure typically formed by layering processes. Use of the term "plate" therefore does not imply structures that are not integrated during their formation. The term "plate" may refer to elements of structures that are integrated during their formation. The term plate as used herein means a structure with at least two relatively large area major surfaces and one or more relatively smaller area edge surfaces. Each major surface may but need not be flat.

Energy conditioning means at least one of filtering, decoupling, and transient suppression of electrical energy propagating between a source and a load.

Filtering means modifying the frequency spectrum of a signal.

Decoupling is a term typically applied to active circuitry. In such circuitry, active devices change their properties, such as trans-conductance, which affects voltage on coupled elements. Decoupling means the minimization of the affects on the voltage of coupled elements due to the changes in the active circuitry.

Transients include spikes due to external effects, such as static discharges and parasitics, such as self induction induced in a circuit.

A first level interconnect is a structure or device that provides an initial circuit connection to an integrated circuit.

An interposer is a structure or device that provides a circuit connection to an integrated circuit.

United States Patents (USPs) 6,018,448 and 6,373,673 disclose a variety of devices that provide electrical energy conditioning. The teachings of USPs 6,018,448 and 6,373,673 are incorporated herein by reference. PCT application PCT/US2004/000218, now published as publication WO 2004/07095, also disclose a variety of devices that provide electrical energy conditioning. The teachings of PCT/US2004/000218 as published as WO 2004/07095

are also incorporated herein by reference.

The novel inventions disclosed herein are structures that have certain performance characteristics that significantly improve at least the decoupling aspect of electrical energy conditioning compared to the devices described above.

SUMMARY OF THE INVENTION

An object of the invention is to provide a novel structure, a method of making the structure, and a method of using the structure, and related circuit configurations and their use, wherein the structure has a certain capacitance and provides energy conditioning that results in an ultra high insertion loss and improved decoupling.

Another object of the invention is to provide a circuit or a portion of a circuit including a novel structure of the invention, a method of making the circuit, and a method of using the circuit.

Additional objects of the invention are to provide devices, circuits, and methods of using them that provide improved energy conditioning over a wide frequency range.

These and other objects of the invention are provided by a novel energy conditioner structure comprising a first electrode including at least a first electrode plate, a second electrode including at least a second electrode plate, and an internal shield structure that is electrically conductive, the shield structure includes a center shield portion between the first electrode plate and the second electrode plate, and the shield structure includes conductive connecting structures including any of conductive vias, holes filled with conductive material, and plates electrically connecting the elements of the shield structure to electrically connect individual layers of the shield structure into a single conductive structure. The shield structure has no or substantially no region forming an external surface of the novel structure. The internally connected shield structures elements have certain geometric values, relative values, relative positions, and shapes, relative to each other and relative to the other elements forming the novel structure.

Generally speaking, plates of the an electrode receive electrical energy along any conductive path that connects to that plate to the portion of the electrode forming part of the external surface of the energy conditioner. Each plate may be generally rectangular shaped,

having two shorter side edges, and two longer side edges. The electrical connection of that plate to the external surface of its electrode may be via the shorter or the longer side edges of the plate. Similarly, the external surface of each electrode may reside in either a shorter side face or a longer side of the energy conditioner. The inventors have determined that the relative location of the external surface portion and internal connection paths (along shorter or longer sides of generally rectangular energy conditioners) affects device performance.

Preferably, substantially all plates of the first electrode have substantially the same shape and are stacked vertically aligned with one another. Preferably, substantially all plates of the second electrode also have substantially the same shape and are stacked substantially vertically aligned with one another. However, plates of the first electrode and the second electrode may have an axis or plane of symmetry and, if so, plates of the second electrode may oriented in the plate of the plates inverted about the axis or plane of symmetry relative to the plates of the first electrode.

These and other objects of the invention are provided by a novel structure comprising:

a first electrode including (A) a first electrode first plate, said first electrode first plate defining (1) a first electrode first plate an inner surface, (2) a first electrode first plate outer surface, and (3) a first electrode first plate edge surface defined by perimeters of said first electrode first plate inner surface and said first electrode first plate outer surface and (B) a first electrode contact region having a first electrode contact region surface for electrically contacting said first electrode;

a second electrode including (A) a second electrode first plate, said second electrode first plate defining (1) a second electrode first plate an inner surface, (2) a second electrode first plate outer surface, and (3) a second electrode first plate edge surface defined by perimeters of said second electrode first plate inner surface and said second electrode first plate outer surface and (B) a second electrode contact region having a second electrode contact region surface for electrically contacting said second electrode;

a conductive shield structure including (a) a plurality of conductive shield plates including at least (1) an inner shield plate, (2) a first outer shield plate, (3) a second outer shielding plate, and (b a shield plate contact structure for electrically contacting to one another said plurality of conductive shield plates;

wherein said first electrode first plate inner surface faces said second electrode first plate inner surface;

wherein (A) said inner shield plate is between said a first electrode first plate inner surface and said second electrode first plate inner surface, (B) said first outer shield plate is faced by said first electrode first plate outer surface, and (C) said second outer shielding plate is faced by said second electrode first plate outer surface; and

said conductive shield structure is designed to be electrically insulated from a circuit.

The shield structure has substantially no portion having a surface forming a part of the surface of the novel structure. The surface of the novel structure substantially entirely encloses the conductive shield structure.

The elements of said novel structure can have certain geometric values, relative values, relative positions, and shapes.

The novel structures may also include, in the stack of conductive layers, also known as conductive plates, additional first conductive layers as part of the first electrode, additional second conductive layer as part of the second electrode, and additional shield layers as part of the shield structure.

Unlike other shielded energy conditioners, the shield structure of this invention does not include electrodes for electrical connection to circuit elements. This lack of a requirement for shield electrodes for connection to circuit elements enables the novel structures of the invention to have substantially or entirely all of one side thereof residing on a conductive surface while maintaining the shield structure out of electrical contact with all circuit elements.

The energy conditioner novel structures may have some of its surface regions defined by electrically insulating material. The novel energy conditioner structures have surface regions formed by at least one contactable surface of the first electrode and the second electrode. The novel structures may have several electrodes, each of which preferable has layers or plates inside the structure that are substantially shielded from layers of all other electrodes of the structure.

The structure preferably has an electrically insulating material between the conductive layers or plates that thereby substantially prevents electrons from moving from one

conductive layer through the insulating material to another conductive layer. The insulating material may be any material that has a dielectric constant. Examples of the insulating material are air, which has a dielectric constant of one, and material specified as X7R, which has a dielectric constant of about 4600, silicon, III-V and II-VI semiconductors, and SiN and Diamond semiconductors. Preferably, the dielectric constant is relatively large in order to maximize capacitance per volume. However, the dielectric constant may be set at least in semiconductor applications by dielectric layers compatible with the semiconductor in question.

The certain geometric values, relative values, relative positions, and shapes of structures of the invention include shapes of each of the plates in the plane defined by the major surfaces of those plates, the locations and relative extensions of the conductive layer contact regions where electrical energy connects to each plate, the thickness of each plate, the spacing between adjacent plates, and the alignment of plates relative to one another.

The energy conditioner structures of the invention may include additional internal structural elements, such as electrically conductive wire lines, conductive via connecting structures, and conductive layer edge interconnection structure The energy conditioner structures of the invention may include interior surfaces defining apertures in the plates through which electrically conductive lines extend. The apertures may form part of vias or tubular-shaped regions extending between plates or layers in the structure. The vias or tubular regions may be filled with material, electrical or conductive, or remain as apertures, that is, not filled with material. These electrically conducting lines may electrically connect to plates of the same electrode or the shield structure while extending through apertures in plates of other electrodes and remaining insulated from those other electrodes or the shield structure as the case may be. The electrode edge interconnection structure, if it exists, serves to electrically interconnect plates of the same electrode to one another, and electrically connects to an edge of plates of the electrode.

The plates of the shield structure are electrically connected to one another. The plates of the shield structure and the conductive structure electrically inter-connecting the plates of the shield structure to one another and substantially enclose the interior plates or layers of the electrodes of the structure of the invention.

A structure of the invention may be formed as a discrete component, such as a component suited for connection to a PC board or for connection to a connector. Alternatively, a structure of the invention may be formed into and form part of another structure, such as a PC board, a connector, a first level interconnect, an interposer, or an integrated circuit, including monolithic integrated circuits. In discrete component embodiments of the invention, the first electrode includes a contact region surface that defines a portion of a surface of the structure, the second electrode includes a contact region surface that defines a portion of the surface of the structure, and the energy conditioner structure has no surface defined by a portion of the shield structure.

In alternative embodiments, the shield structure may have a surface region defining a recessed portion of the surface of the structure.

Discrete component and PC boards that incorporate the novel structures of the invention may be formed by conventional layering and firing techniques. Wire lines may be either formed monolithically, or formed separately and then inserted into the apertures or formed in the apertures.

In both PC board and integrated circuit embodiments, certain ones of the electrodes' contact region surfaces in discrete component embodiments that define portions of the surface of the structure do not exist, per se. Instead, the regions where those surfaces would otherwise define termination of a discrete component are formed in contact with electrically conductive material connecting to vias and/or extending from and/or through some portion of the PC board, substrate, first level interconnect, interposer and/or integrated circuit beyond the regions containing the first electrode, the second electrode, and/or the shield structure.

Preferably, the inner shield plate extends, in the plane defined by its major surfaces, beyond the edges of adjacent plates of the first and second electrodes such that, with the possible exceptions noted below, any line passing through both of the adjacent plates (i.e., a plate of the first electrode and a plate of the second electrode) also passes through and/or contacts the inner shield plate. An exception exists wherein, in some embodiments, relatively small regions of the plates of each of the first and second electrodes extend beyond the extension of the shield plates where they contact one or more internally positioned conductive layer interconnection structure(s). The internal conductive layer interconnection structure

functions to electrically connect substantially all plates of the first electrode to one another and/or substantially all plates of the second electrode to one another. In addition or alternatively, at least a portion of the inner shield plate generally extends a distance beyond the extension of adjacent plates of the first and second electrodes by at least one, preferably at least 5, more preferably at least 10, and most preferably at least 20 times the distance separating the inner shield plate from an adjacent plate.

The electrode plate interconnection structure is a structure that electrically contacts portions of all or substantially all of the plates of the electrode, thereby electrically connecting the plates of the electrode to one another. The electrode plate interconnection structure for one electrode does not, inside of the energy conditioner structure, contact the plates of any other electrode or the shield structure. Electrode interconnection structure typically exists within these discrete components.

In PC board, connectors and integrated circuit embodiments of structures of the invention, there may be no electrode or shield structure edge interconnection structure. Instead, typically, there will be structure electrically interconnecting all plates of the same electrode or the shield structure which includes electrically conducting wire lines that connect to plates of the same electrode or the shield structure. The electrically conducting wire lines that connect to plates of one electrode do not electrically connect to plates of other electrodes. No wire lines connect to the shield structure. Preferably, the electrically conducting wire lines connected to plates of one electrode pass through apertures in plates of other electrodes and the plates of the shield structure such that those wire lines do not electrically connect to the plates of the other electrodes or the shield structure.

In addition, as shown in figures herein, in the energy conditioner, to provide for internally located, common shielding conductive vias are provided thereon is arranged between the first and second electrodes sheets and are utilized to electrically connect the internally located, shielding conductive layers to one another.

Conductive coupling or conductive connection is accomplished by one or more via-hole(s) disposed in the respective insulating sheets and coupling to and/or thru each shielding conductive layer as needed. Via structures whether filled or not, are normally found in a non-parallel relationship to the disposed conductive layerings, shielding or non-shielding.

Via structures are normally disposed beyond the perimeter of any non-shielding conductive layers, however it is readily contemplated that vias may be disposed thru the non-shielding conductive layers provided that an insulating area is disposed insuring a direct, but non-conductive relationship between via structures and the various non-shielding layers.

The inventors also contemplate use of the invention in nano technology fabrication wherein the invention provides reduced parasitics between very closely spaced conditioner electrodes.

Parasitic energy that would exist in prior art non shielded capacitors is greatly reduced by containment of each respective electrode within a portion of the conductive shielding structure. The conductive shielding structure may be referred to as a conductive shielding cage-like structure.

Fabricating preferred embodiments of bulk devices includes providing insulating sheets having conductive patterns thereon and in some embodiments via-holes there through, laminating and firing. However, any other fabrication method may be used.

For example, the insulating sheets may be fired before being laminated. In addition, the composite component of various preferred embodiments of the present invention may be produced by the following method. After an insulating layer including a paste insulating material is provided by printing or other suitable methods, a paste conductive material is applied on a surface of the insulating layer to provide a conductive pattern and a via-hole. Next, the paste insulating material is again applied on the layer to provide another insulating layer. Similarly, by applying the paste insulating material in sequence, a composite component having a multi-layered structure can be produced.

BRIEF DESCRIPTIONS OF THE FIGURES

FIG 1A shows an exploded perspective view of layers of a first embodiment of a novel energy conditioning structure of the invention;

FIG. 1B shows a perspective view of the energy conditioning structure of FIG. 1A;

FIG. 1C shows a partial exploded perspective view of some elements of the energy conditioning structure of FIG. 1A illustrating inset distances between certain layers;

FIB. 2A is an exploded perspective view of layers of a second embodiment of a novel

energy conditioning structure of the invention;

FIG 2B is an exploded perspective view of layers of a second embodiment of a novel energy conditioning structure of the invention excluding upper and lower dielectric layers;

FIG. 2C is an exploded perspective view of layers of a second embodiment of a novel energy conditioning structure of the invention excluding upper and lower dielectric layers and excluding upper and lower shield structure layers;

FIG. 3A shows a filter arrangement including an energy conditioner disposed on surface including a conductive line;

FIG 3B shows a filter arrangement including an energy conditioner disposed on a conductive line and having only a single electrode connected;

FIG 3C shows a filter arrangement including an energy conditioner disposed on a conductive line;

FIG 3D shows a filter arrangement including an energy conditioner disposed on a conductive line;

FIG. 4A shows a filter arrangement including an energy conditioner circuit with A and B electrode contacts connected to separate conductive lines;

FIG. 4B shows a filter arrangement including an energy conditioner circuit having another an energy conditioner with different geometric ratios of A and B electrode contacts connected to separate conductive lines.

FIG. 5A shows a filter arrangement including an energy conditioner disposed transversely on a conductive line over an aperture in the line;

FIG. 5B shows a filter arrangement including an energy conditioner disposed longitudinally on a conductive line over an aperture in the line;

FIG. 6 is a perspective view that shows a filter arrangement including in perspective view including an energy conditioner disposed over an aperture in a rectangular conductive component;

FIG. 7 is a plan view that shows a filter arrangement including a energy conditioner disposed over a circular aperture in a conductive ring shaped component;

FIG. 8 is a plan view that shows a filter arrangement including three energy conditioners disposed across an aperture in an elongate generally elliptically shaped

conductive piece;

FIG. 9 is a plan view of a filter arrangement including two energy conditioners symmetrically arranged off opposite sides of a conductive circuit line;

FIG. 10 is a plan view of a circuit portion including a plurality of conductive lines and various arrangements of energy conditioners on and near the lines conditioning energy for each line;

FIG. 11 is a plan view of a circuit portion including a plurality of conductive lines and various arrangements of energy conditioners disposed on the lines conditioning energy for each line;

FIG. 12 is a plan view of a circuit portion including a plurality of conductive lines and various arrangements of energy conditioners disposed on the lines in which each energy conditioner connects to one or more lines;

FIG. 13A is an exploded perspective view of an filter arrangement including an energy conditioner configured to fit into and span an aperture in a ring formed of conductive material;

FIG. 13B is a side view of the filter arrangement of FIG. 13A;

FIG. 14 is a schematic view of a filter arrangement including an energy conditioner having a single electrode connected;

FIG 15 is a schematic of a complete circuit including a filter arrangement including energy conditioner spanning an aperture in a conductive loop;

FIG. 16 is a schematic view of a complete circuit including an energy conditioner and a metal layer capacitively and inductively coupled and conductively isolated from the energy conditioner;

FIG. 16 is a schematic view of a complete circuit including an energy conditioner and a capacitively and inductively coupled and conductively isolated metal layer;

FIG. 17 is a schematic of a complete circuit including an energy conditioner connected across the source and the load;

FIG. 18 is a schematic of an energy conditioner connected across the source and drain electrodes of a Field Effect Transistor (FET);

FIG. 19A is a schematic of an energy conditioner having one electrode connected to

source or drain of a FET and no other connections to provide a fast charge storage for memory;

FIG. 19B is a schematic sectional view of a semiconductor wafer showing in high level connection of the energy conditioner to the FET of FIG. 19A;

FIG. 20A is a schematic of an energy conditioner having both electrodes connected to source or drain of a FET and no other connections to provide a fast charge storage for memory;

FIG. 20B is a schematic sectional view of a semiconductor wafer showing in high level connection of both terminals of the energy conditioner to the FET of FIG. 20A;

FIGs. 21 and 22 are schematics illustrating complete circuits with various filter arrangements including energy conditioners of the invention;

FIGs. 23A-C are perspective views that show filter arrangements including another novel energy conditioner;

FIG. 24 is a perspective view that shows a filter arrangement including another novel energy conditioner in a circuit arrangement;

FIG. 25A is a side schematic view of another novel energy filter;

FIG. 25B is side sectional view of the energy filter of FIG. 25A;

FIG. 25C is a schematic identifying the internal conductive layers shown in FIG. 25B;

FIG. 26A is a side section view of a filter arrangement including the novel energy conditioner illustrated in FIGS. 25A-25C;

FIG. 26B is a plan view of the filter arrangement of FIG. 26A; and

FIG. 27 is a schematic in plan view of a filter arrangement including a variation of the novel energy filter of FIGs. 25A-25C.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1B shows an energy conditioning structure 1 including a first electrode contact 10, a second electrode contact 20, and a central region 30. The central region 30 has surfaces formed from one or more dielectric materials 40. The surfaces of the first electrode contact, the second electrode contact, and the dielectric material preferably define the entirety of the surface of the energy conditioning structure.

FIG. 1A shows a sequence of layers internal to energy conditioning structure 1. FIG 1A shows the sequence of layers from top to bottom being dielectric material layer 50, shield structure first conductive layer 60, dielectric material layer 70, second electrode's internal conductive layer 80, dielectric material layer 90, shield structure's second conductive layer 100, dielectric material layer 110, first electrode's internally connected conductive layer 120, dielectric material layer 130, shield structure's third conductive layer 140, and dielectric material layer 150.

FIG. 1A shows conductive pathways extending between layers enabling electrical connection of the shield structure's layers to one another. These pathways are referred to as vias, and FIG. 1A shows vias 160A, 160B. There should be at least one conductive pathway electrically connecting the layers of the shield structure to one anther. Some of these conductive pathways may pass through apertures in the electrodes' internally connected conductive layers, remaining insulated from those layers by a region of dielectric material between the conductive material in the via and the conductive material forming the electrodes' internally connected conductive layers.

Preferably, these conductive pathways 160A, 160B extend along paths outside the planar extent of the electrodes' internally connected conductive layers. Preferably, there are a plurality of conductive pathways like 160A, 160B disposed to ring each one of the electrodes' internal conductive layers. Preferably, there is a sufficient density of conductive pathways like 160A, 160B ringing each one of the electrodes' internal conductive layers and connected to the conductive layers of the shield structure so that the shield structure as a whole provides a Faraday cage type of effect for each internal conductive layer of each electrode. That is, preferably, the shield structure shields electromagnetic field oscillations at relevant frequencies located adjacent each on of the conductive layers of the electrodes from other conductive layers of the conductive electrodes, and shields all of the conductive layers of the electrodes from electromagnetic oscillations originating outside the shield structure.

FIG 1C illustrates inset/offset of edges of the internal layers in energy conditioner 1 from one another. FIG 1C. shows inset distance "A" of the left side of the first electrode's internally connected layer 120 from shield structure's layer 100, and a similar outset distance "A" of the right side of the first electrode's internally connected layer 120 from the right side

end of shield structure's layer 100. Layer 80 is similarly offset, but in the opposite direction, relative to the left and right ends of shield structure's layer 100. The offset of the right side end of layer 120 relative to layer 100 enables layer 120 to internally contact the first electrode's contact 10, without also contacting layer 100 to the first electrode. The offset of the left side of the end of layer 80 relative to layer 100 enables layer 80 to internally contact the second electrode's contact 20 without also contacting layer 100 to the second electrode.

FIGS. 1A-1C show that the shield structure does not contact the first electrode, does not contact the second electrode, and does not have an electrode for contact to a circuit element. FIGS. 1A-1C show the shield structure embedded inside dielectric material so that the surface of energy conditioner 1 does not include any surface of the shield structure.

FIGS 1A-1C are exemplary in that they show only one conductive layer for each one of electrodes A and B.

In most applications, each energy conditioner 1 would include a set of more than one conductive layer for each electrode.

In some applications, the first electrode and/or the second electrode do not form end caps covering right and/or left (as shown in FIG 1B) ends of energy conditioner 1. Instead, the electrodes form part of a surface of the energy conditioner on any one of the front, back, left and right sides of the structure.

In some applications, the first electrode and/or the second electrode do not form end caps covering right and/or left (as shown in FIG 1B) ends of energy conditioner 1, and do not form part of the left, right, front, or back (as shown in FIG. 1B) surfaces. Instead, they form part of the top and/or bottom surfaces of energy conditioner 1, and are connected to their respective internally conductive layers via additional vias (not shown) extending through and be insulated from layers of the shield structure and layers connected to other electrodes.

In some applications, each energy conditioner 1 includes more than 2 electrodes. In these embodiments, each electrode contacts at least one conductive layer internal to the energy conditioner, and each such conductive layer has an outset or tab portion extending in the planar direction beyond the extent of the shield structures layers. That tab portion contacts to an electrode having a surface available for electrical contact with other circuit elements. The surface of this electrode may be located on any surface of the energy

conditioner; top; bottom front; back,; left; or right side.

The FIGS. 1A -1C embodiment shows the shield structure formed from a series of conductive layers which are electrically connected to one another such that each layer of each electrodes is separated from a layer of any other electrode by a layer of the shield structure. Preferably, the shield structure's conductive layers are substantially integral layers. However, regions of the conductive layers of the shield structure may be removed so long as sufficient regions of each conductive layer of the shield structure remain to provide shield structure like device performance, such as decreased internal inductance compared to non-shielded energy conditioner structures. For frequency ranges up to about 10 gigahertz, this requires that the spacing between conductive regions of the same conductive layer of the shield structure be less than one centimeter, preferably less than 5 millimeters, and more preferably less than about one millimeter.

While not preferred, each conductive layer of the shield structure may be replaced by a grid work or mesh or array (regular or irregular) of conductive lines having line separations of no more than one centimeter, and preferably no more than one millimeter, line widths and depths greater than 100 Angstroms, more preferably at least 1000 Angstroms in width, and most preferable at least one micron in width.

Preferably, the insulating spacing or distance between conductors of any electrode and the conductor forming the shield structure is at least 100 Angstroms, preferably at least 1000 Angstroms, more preferably still at least 1 micron, and most preferably at least 100 microns. The minimum spacing is defined in part by the dielectric constant, dielectric strength, and voltage fluctuations of the intended use of the energy conditioner 1.

Thus, the FIG. 1A-1B embodiment is exemplary of only one simplified version of the energy conditioner of the invention.

FIG. 2A shows a sequence of layers of energy conditioner 200 from top to bottom as dielectric material top layer 210, conductive outer top shield structure layer 220, conductive inner top shield structure layer 230, conductive first electrode layer 240, conductive middle shield structure layer 250, conductive second electrode layer 260, conductive inner bottom shield layer 270, conductive outer bottom shield layer 280, and dielectric material bottom layer 290. Not shown are dielectric layers between each pair of adjacent conductive layers. In

plan view, each shield structure layer extends beyond three sides of each electrode layer. In plan view, electrode layer 240 has portion 240a extending beyond the shield structure's layers, and electrode layer 260 has portion 260a extending beyond the shield structure's layers. The portions 260a and 240a are on opposite ends of energy conditioner 200. Structure 200 differs from structure 1 in the existence of the adjacent top shield structure layers 220, 230, which are only separated from one another by dielectric. Structure 200 differs from structure 1 in the existence of the adjacent bottom shield structure layers 270, 280, which are only separated from one another by dielectric.

FIG 2A. also shows via structures 300 traversing the shield structure layers 230, 250, 270. The vias also travers the intervening dielectric layers, which are not shown. Vias 300 do not traverse the dielectric material layers 200 or 290.

FIG. 2B shows the layers without the top and bottom dielectric material layers.

FIG. 2C shows the layers without the top and bottom dielectric material layers and without the top and outer two shield layers 220, 280. FIG. 2C shows the inset distance B which is the distance, in a plan view, that shield structure layer 250 extends beyond an edge of electrode layer 240.

Energy conditioner 200 includes electrode contacts like electrode contacts 10, 20 of energy conditioner 1, which are not shown in FIGs. 2A-2C.

In one alternative embodiment, outer shield layers 220, 280 are not electrically connected to the other layers of the shield structure, and outer shield layers are each individually electrically isolated.

In another alternative embodiment, outer shield layers 220, 208 are not electrically connected to the other layers of the shield structure, and outer shield layers are each electrically connected to one another via additional vias.

In another alternative embodiment, the layered structure including the shield structure or structures shown in FIGS. 1A - 2C are embedded in a monolithic layered structure comprising either a PC board, an interposer, or a semiconductor chip. In these embodiments there may be no electrode contact surface. Instead, there may be an extension of at least one conductive layer of each electrode beyond the planar extent of the cage like shield structures such that the each electrode connects to a line of a circuit.

Various relationships between portions of circuits and the energy conditioners of the invention are shown in FIGs. 2-12. These figures illustrate novel geometric inter-relationships between energy conditioners and circuit elements which are within the scope of this invention.

Hereinafter, energy conditioners of the invention will be referred to as X2Y'.

FIG. 3A shows an X2Y' having its end cap electrodes disposed longitudinally along a conductive line of a circuit. Both end caps are electrically connected to the conductive line of the circuit.

Fig. 3B shows an energy conditioner X2Y' having one electrode end in contact with a conductive line of a circuit, an no other electrodes contacting the circuit. In this embodiment, the X2Y' energy conditioner does not require a second electrode contact. Therefore, it may be manufactured with or without the surface contact portion of the second electrode.

FIG. 3C show an X2Y' having dimension less than the width of the conductive line, and its electrode end caps oriented transverse to the direction of extension of the conductive line of a circuit.

FIG 3D show an X2Y' having dimension less than the width of the conductive line, and its electrode end caps oriented at an angle that is between transverse and longitudinal relative to the direction of extension of the conductive line of a circuit.

FIG. 4A shows an X2Y' having each one of its electrode end caps connected to a different one of two side lines that each in turn connect to a different point along a conductive line of a circuit. Alternatively, the two side lines could connect to the same point along the conductive line of the circuit.

FIG. 4B shows an alternative to FIG 4A wherein the length of each end cap of each electrode of the X2Y[is greater than the width of each side line.

FIG. 5A shows a conductive line of a circuits having an aperture upon which an X2Y' is disposed. The X2Y' contact s the line of the circuit on opposite sides of the aperture and the end caps of the X2Y' are oriented along the longitudinal direction of the line of the circuit.

FIG. 5B show and a conductive line with an aperture and an X2Y' transversely over the aperture such that the X2Y' end caps are along the same point along the length of the line

of the circuit.

FIG. 6 shows an square shaped metal piece having an aperture and a connection arm, and an X2Y' disposed over the aperture such that the end caps of the X2Y's are in electrical contact with opposite sides of the metal piece. In alternative embodiments the metal piece is oblong, annular, or rectangular, and the X2Y' is oriented at various angles relative to the extension of the arm to provide suitable phase cancellation. The arm connects to a line of a circuit, to provide energy conditioning. Alternatively, the X2y' may fit into a seat or recess in the aperture, or may span a length of the aperture and fit into the aperture and contact opposite surfaces of aperture.

FIGs. 7 and 8 show alternative annular shapes and multiple X2Y' filters similar to FIG. 6.

FIG. 9 shows a filter arrangement in which side lines extend symmetrically from a circuit line, each side line contacting one or more terminals of an X2Y'. Preferably, each side line forms a pad upon which the X2Y' resides such that both end caps of the X2Y' connect and electrically connect to the pad.

Fig. 10 shows portions of four circuit lines on a substrate, such as is often found in digital electronics on semiconductor chips, PC boards, and other substrates. FIG. 10 also shows various filter arrangements incorporating X2Y's connected to the various circuit lines.

FIG. 11 show another arrangement of circuit lines on a substrate along with one or more X2Y's in various orientations on each circuit line.

FIG. 12 is similar to FIGs. 10 and 11. However, FIG. 12 shows some X2Y's spanning two circuit lines such that the spanning X2Y' has one electrode connected to one circuit line and the other electrode connected to the other circuit line. FIG. 12 also shows X2Y' element C having three electrodes, with one electrode connected to each one of three lines. Alternatively, an X2Y' structure (a structure with an internally floating shield structure), could have more than three electrodes, for example, one electrode for each parallel circuit line. In bus architectures this would enable a single X2Y' devise to span a series of bus lines and condition the energy along all of those lines. Such a multi electrode X2Y' device could be disposed as shown in FIG. 12 perpendicular to the extension of the wire lines. Alternatively, the multi electrode X2Y' could be disposed at an angle other than a right angle relative to the

extension of the parallel circuit lines as required to register each X2Y' electrode onto each bus line.

FIG. 13a shows an X2Y' and apertured conductive piece designed such that the X2Y' has the same dimension as the aperture and can fit into the aperture as shown in FIG. 13B.

FIG. 14 sows a circuit line with a side line projecting therefrom and connecting to one electrode of an X2Y'. Since no other electrode of the X2Y's is required, the other external electrode for the X2Y' need not be fabricated.

FIG. 15 shows a filter arrangement previously discussed connected to a complete circuit.

FIG. 16 shows a complete circuit with an X2Y' across the source and the load. In addition, FIG. 16 shows a metal layer of specified dimensions insulatively spaces by a specified distance from a surface of the X2Y'. The size, shape, and spacing of the metal layer from the X2Y' and other components affects capacitive and inductive coupling to the metal layer. Therefore, the size, shape, and spacing of the metal layer from the X2Y' and other components of the circuit provide for frequency and phase tuning of energy conditioning provided by the X2Y'.

FIG. 17 shows a complete circuit with and X2Y' having its two electrodes across the load.

FIGs. 18-20 schematically illustrate application of X2Y' structures to FETs and FET based memory. FET meaning Field Effect Transistor. However, the circuit disclosed are equally applicable to bipolar transistors.

FIG. 18 represents an X2Y' connected across the source and drain of a FET to provide for example, filtering of high frequency components in the source drain voltage.

FIG. 19A shows an X2Y's having one electrode connected to the drain (or to the source) of a FET. This allows capacitive charging of X2Y's's electrodes. X2Y's have very small internal inductance. Therefore, charging time is fast, enabling fast read or write memory of a voltage or charge state. FIG. 19B shows one possible architecture for incorporating the X2Y' structure and a FET structure into a semiconductor chip, in which a conductive line disposed on the surface of the FET's source or drain to a point contacting en electrode layer of the X2Y' .

FIGS. 20A and 20B are analogs of FIGS. 19A and 19B showing bulk (A) and integrated (B) formation of a memory having connection to both electrodes of an X2Y'.

FIG. 21 shows a complete circuit in which a series of two X2Y's are disposed across the load. Additional X2Y's (3, 4, 5, etc) can be added to the series.

FIG. 22 shows a complete circuit in which an X2Y' is disposed across the load and another X2Y' is disposed connected to a side line, to provide energy conditioning at both extreme ends of the frequency spectrum.

FIG. 23A shows a filter arrangement portion of a circuit including another novel energy conditioner (X2Y') of the invention. The X2Y' of FIG. 23A is a the same as any of the energy conditioners disclosed herein above except that it includes a conductive shell enclosing the A and B electrode structures, the ground shield structure, and the dielectric material. Thus, the FIG. 23A X2Y' includes a floating isolated internal shield structure, an A electrode conductively connected to the conductive shell, and a B electrode structure also conductively connected to the conductive shell. As shown in the filter arrangement of FIG. 23A, this X2Y' is disposed on and in conductive contact with a circuit line. The longer side of the X2Y' is parallel to the circuit line.

FIG. 23C shows the X2Y' of FIG. 23A alternatively arranged so that a shorter side is parallel to the circuit line.

FIG. 23B illustrates an alternative filter arrangement including the X2Y' of FIG. 23A in which the conductive shell of the X2Y' forms the connection between to terminals of a circuit line.

FIG. 24 shows a circuit arrangement including another novel X2Y' energy conditioner. The X2Y' energy conditioner is internally structurally the same as any of the previously disclosed X2Y' structures. However, it includes externally symmetrically placed conductive connections of the right and left side electrode terminal contacts. The filter arrangement in FIG. 24 shows circuit line portions terminating, and the X2Y' externally symmetrically placed conductive connections completing the conductive path of the circuit line portions. Alternatively, the circuit line may have no break, and this X2Y' structure may be disposed on the circuit line in the same configuration shown in FIG. 24, or in the alternative orientation shown in FIG. 23C. In either orientation, the X2Y"s internal electrode structures are both

electrically connected to the circuit line path on both sides of the X2Y'.

FIG. 25A-25C illustrate another novel energy conditioning structure designed for coupling without electrically contacting a circuit line.

FIG. 25A shows a side view of this novel X2Y' structure and schematically illustrates the internal location of capacitive/inductive coupling pads for two electrodes of this X2Y'.

FIG. 25B shows a side section of the X2Y' of FIG. 25A including an optional metallic casing on all sides except the bottom side, an A electrode pad recessed from the bottom, a B electrode pad recessed from the bottom, an A electrode plate, a B electrode plate, and shield three structure layers such that two layers of the shield structure sandwich each layer or plate of the A and B electrodes. Dielectric material exists between the conductive layers to fix them in position relative to one another. Preferably, there is a dielectric layer of a well defined and uniform thickness below the A and B electrode pads. As in all previous embodiments, the shield structure electrically floats in potential. Different from all previous embodiments, the A electrode and the B electrode also float; they do not electrically contact any line of a circuit. Preferably, the lower surface is material that will wet with a conductive metal such as conventional solder, indium or indium-tin. In use, the bottom surface of the X2Y may be soldered using these metals to a conductive line of a circuit. Use of a metal solder connection enables the dielectric spacing defined by the thickness of the dielectric layer below the electrode pads to define distance between the metal of the circuit line and the pads, thereby providing reproducible inductive/capacitive coupling.

FIG. 25C shows the sequence of conductive layers within the X2Y' of FIGS. 25A and 25B. FIG. 25C also shows the offset of the ends of the layers at the left side of the layers shown in FIG. 25B. However, as with other embodiments, vias may be used so that the shield layers may extend beyond the planar extent of the electrodes' conductive layers.

FIG. 26A shows in side partial sectional view a filter arrangement including an X2Y' of FIG. 25A-25C wherein the X2Y's energy conditioner is disposed on a conductive line of a circuit on a substrate. The internal locations of the A electrode pad and the B electrode pad are illustrated by dashed lines.

FIG. 26B is a plan view of the filter arrangement of FIG. 26A also showing the perimeters of the A and B electrode pads in dashed lines.

FIG. 27 is a schematic in plan view of a filter arrangement including a variation of the novel energy filter of FIGs. 25A-25C. The X2Y' energy filter of FIG. 27 is similar to the X2Y' of FIGs. 25A-25C in that it includes pads that are capacitively/inductively coupled and not in electrical contact with the circuit line, and the filter arrangement includes this X2Y' disposed on the conductive line. In contrast with the FIGs. 25A-25C X2Y', the X2Y' of FIG. 27 includes more than 2 electrodes. Specifically, it includes three electrodes and three electrode pads. Pads 1 and 2 are oriented transverse to the extension of the circuit line. Pad 3 is oriented longitudinally spaces from pads 1 and 2 relative to the extension of the circuit line. This X2Y' includes the X2Y floating shield structure substantially individually enclosing each of the electrode structure's layers to provide very low inductance and high differential impedance effects between electrodes. If connected to a conductive line such that the pad 1 and pad 2 are coupled to the line as shown, they may experience time dependent transverse voltage differences and filter out those voltage differences. Moreover, the time dependent longitudinal voltage differences on the line should be filtered out by the existence of pad 3 longitudinally disposed relative to pads 1 and 2.

The capacitive/inductive coupling illustrated by the X2Y' energy filter of FIG. 25A to FIG. 27 is compatible with all of the filter arrangements previously disclosed herein. Use of the capacitive/inductively coupled type of X2Y' structure in any of the previously discussed filter arrangements is contemplated.

While FIG. 27 shows only 3 pads and discloses only three corresponding internally shielded electrodes, the inventors contemplate that more contact pads and electrodes may be useful. Specifically, the inventors recognize that high frequency propagation modes along a circuit line may be in various modes defined for example by solutions to boundary value equations defining the dimension of the circuit line and related transmission line characteristics. This suggests that an array of contact pads at various spatial distances from one another may be useful for filtering out high frequency modes from power or signal transmitted along a circuit line. Such arrays may include more than 3, such as from 4 to 500 pads and corresponding internally shielded electrode structures.

The combination of various electrodes and a conductive shielding structure can create a state of effective differential and common mode electromagnetic interference filtering

and/or surge protection. Additionally, a circuit arrangement utilizing the invention will comprise of at least one line conditioning circuit component constructed with shaped electrode patterns that are provided on various surfaces of dielectric material with at least a portion of these respective electrode surfaces or edges operable for conductive coupling for electrically coupled energy transmissions to electrical conductors of the circuit.

The variously selected electrode patterns, dielectric material employed, and positioning and usage of an intervening, conductive shielding layer or structure create a commonality between paired, but oppositely positioned (relative to one another) electrodes operable for producing a balanced (equal but opposite) circuit arrangement position within the electrical component when it is coupled line-to-line between the electrical conductors and line-to-ground from the individual electrical conductors to internal, conductive shielding layer or structure within the component for circuit energy conditioning operations.

The particular electrical effects of the multi-functional energy conditioner are determined by the choice of material between the electrode plates and the use of an internally positioned, conductive shielding layer or structure which effectively house a substantial portion of the electrode layers within one or more Faraday-like, shielding structures.

The dielectric material used in conjunction with at least two oppositely positioned electrode plates with a conductive shielding layer or structure spaced in between will combine to create an line-to-line capacitance value that is approximately ½ the value of the capacitance value of either one of the two line-to-shielding layer capacitors created, when energized.

If a metal oxide varistor (MOV) material is used, then the multi-functional energy conditioner will have over current and surge protection characteristics provided by the MOV-type material. The conductive shielding layer or structure in combination with the electrode plates will form at least one line-to-line capacitor and at least two line-to-ground capacitors, and will be operable for providing differential and common mode filtering.

During transient voltage conditions, varistor material, which is essentially a non-linear resistor used to suppress high voltage transients, will be operable to limit the transient voltage conditions or over voltage spikes that may appear between the electrical conductors.

The inventors contemplate embodiments in which vias or apertures are defined by conductive surfaces such that those conductive surfaces form a conductive pathway that can

mechanically and electrically contact to one or more conductive layers or surfaces in the structures.

The inventors also contemplate that plates may be irregularly shaped as opposed to square, rectangular, or generally round, depending for example upon desired application.

The inventors also contemplate that vias may pass through conductive layers, such as layers forming the non-shielding electrodes, and layers forming the shielding electrode, without electrically contacting those layers in order to electrically connect, for example, layers of one electrode structure to one another without shorting that electrode structure to another electrode's structure.

The inventors contemplate modifying the energy conditioner embodiments disclosed in USPs 6,018,448 and 6,373,673 PCT/US2004/000218 (now published as WO 2004/07095) by modifying their conductive shield structure so that is designed to be conductively isolated from a circuit to which the conditioner's electrodes are designed to be conductively or capacitively/inductively connected. Thus, the conductive shield structure of those embodiments may be modified to cover the entire outer surface of the conductive shield structure with dielectric material. Optionally, some portion of the conductive shield structure may be uncovered, but recessed from adjacent surface regions of the structure.

The number of plates or the shield structure may be 1, 3, at least 3, at least 5, at least 7, at least 9, or at least 21. The ratio of the total surface area of the shield structure to the total surface area of an electrode of the structure may be at least0.1, at least 0.5, at least 1, at least 3, at least 5, or at least 10. The number of electrodes in any structure may be at least 2, at least 3, at least 4, at least 6, at least 10, at least 16, at least 32, or at least 64.

Preferably, the electrodes of the novel structures are designed to connect or capacitively/inductively couple to or are formed connected or capacitively/inductively coupled to conductive lines of a circuit, and the conductive shield structure is designed to be conductively insulated from lines of the circuit.